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MISSION PLANNING AND ANALYSIS DIVISION

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PROJECT APOLLO

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# AS-503A/504 REQUIREMENTS FOR THE RTCC: PREFLIGHT INFORMATION

By Donald R. Sellers

## SUMMARY

This document presents a preliminary definition of the preflight information required for direct support of the Real-Time Computer Complex (RTCC) program. The information documented here applies only to those processors formulated by the Mission Analysis Branch (MAB) for missions AS-503A and AS-504. The processors for which preflight information has been defined include

1. Translunar Injection Processor
2. Midcourse Correction Processor
3. Return-to-Earth Processor
4. Reentry Processor

Not included in this document are the preflight numbers associated with Lunar Orbit Insertion Processor and the S-IVB burn model, both of which are currently in the process of formulation.

The text contains a complete description of the aggregate and a definitive breakdown of the quantities applicable to each processor. It is strongly emphasized that this definition of the preflight information is preliminary.

## INTRODUCTION

This section contains a definition and analysis of the RTCC preflight information. For clarity and convenience, the RTCC preflight data is broken down into four main groupings.

Parameters.- A parameter is defined as a quantity which varies during a launch window. The parameters defined in this note are functions of launch azimuth, injection opportunity, and launch day. Each parameter, since it is a function of several variables, is stored in table-lookup form. The exact number of numerical quantities contained in a table is entirely dependent on the sensitivity of the parameters.

Constants.- A constant is defined as a numerical quantity which remains constant throughout a given launch window.

Coefficients.- Several polynomials are included in the RTCC formulation of the MAB programs. The coefficients associated with these polynomials are stored preflight.

Numerical Constants.- There are two groups of numerical constants stored in table-lookup forms. These numbers define the reentry target lines for the Return-to-Earth Processor and specify the final phase reference trajectory for the Reentry Processor.

## SYMBOLS

| | |
|---|---|
| RTCC | Real-Time Computer Complex |
| MAB | Mission Analysis Branch |
| ACR | Auxiliary Computer Room |
| TLI | translunar injection |
| MCC | midcourse correction |
| DPS | descent propulsion system |
| LM | lunar module |
| LOI | lunar orbit insertion |
| ASPO | Apollo Spacecraft Project Office |
| LMDS | Lunar Mission Design Section |
| MAS | Maneuver Analysis Section |
| LTS | Lunar Trajectory Section |

# ASSUMPTIONS

Three basic assumptions were made to determine the size of the preflight data tables. These assumptions were determined for a worst possible case in order to maximize the number of quantities required for preflight storage.

1. a 26° band of launch azimuths

2. 3 injection opportunities per launch day

3. a maximum number of 5 launch days per month.

By assuming as an upper bound the maximum stipulated above, the preflight storage for realistic assumptions should never exceed the maximum number of storage spaces allotted. Based on these assumptions, 5539 numerical quantities will be needed preflight to support MAB programs. The table below shows the numerical sum associated with each grouping.

| | Numerical quantities |
|---|---|
| Parameters (45) | 4758 |
| Constants (112) | 122 |
| Polynomial coefficients | 434 |
| Numerical constants (2 sets) | 225 |
| TOTAL | 5539 |

It should be noted that only the parameters will change if the basic assumptions listed above are redefined. Obviously, these assumptions will vary, and the actual size of the parameter tables may depend entirely on which month the launch takes place. In contrast, the remaining three groups remain constant after final definition of the RTCC formulation.

A substantial reduction in the total sum can be attained with realistic dimensioning of the parameters. In comparison test case, dimensioning of the parameters was made in accordance with the following launch window configuration:

1. a 26° range of launch azimuths

2. two injection opportunities, and

3. 3 launch days per month.

These assumptions reduced the number of the parameters from 4758 to 2751 quantities. The remaining three groups were unchanged. This reduced the total preflight information requirements from 5539 to 3532 quantities.

The remainder of this note describes the preflight information for each processor. The initial basic assumptions are used to dimension the parameters. Consequently, the parameter tables will reflect the maximum requirement.

## TRANSLUNAR INJECTION AND MIDCOURSE CORRECTION PROCESSORS[1]

This section describes in detail the parameters, coefficients, and constants associated with the Translunar Injection (TLI) and Midcourse Correction (MCC) Processors. Most of the preflight data defined in this section is used by both processors; consequently, both processors are treated as a single entity. A definition of the individual parameters and constants is presented in table I.

The TLI and MCC processors require the largest share of the preflight data, 3631 quantities. The sum associated with each grouping is shown below.

| | Numerical quantities |
|---|---|
| Parameters (23) | 3298 |
| Constants | 14 |
| Coefficients | 319 |
| TOTAL | 3631 |

The parameters, constants, and coefficients can also be categorized functionally. The following table lists the functional categories and their requirements.

| | Numerical quantities |
|---|---|
| I. Nodal targeting (x,y,z, and t) | 1560 |
| II. Targeting objectives and first guesses | 1050 |
| III. Full-mission select mode | 540 |

[1]The RTCC formulation for the TLI and MCC processors is described in references 1 and 2.

| | | |
|---|---|---|
| IV. | Polynomial constraint on DPS | 35 |
| V. | Maximum $\Delta T_{TLI-pc}$ constraint | 90 |
| VI. | Earth orbit insertion state vector | 24 |
| VII. | TLI polynomials[2] | 268 |
| VIII. | Other parameters | 50 |
| IX. | Constants | 14 |
| | TOTAL | 3631 |

The remainder of this section briefly describes each category and delineates precisely the proposed dimensioning of each parameter.

I. Nodal Targeting. Mildly dispersed translunar trajectories can be corrected back to the nominal flight plan through implementation of the XYZ midcourse mode. This mode targets the spacecraft to pass through the node formed by the planes of the nominal approach hyperbola and the desired lunar parking orbit at the nominal arrival time. A definition of the parameters itemized below is given in table I.

Parameters: $T_{nd}$, $\phi_{nd}$, $\lambda_{nd}$, $R_{nd}$

Dimensions per parameter: 26 discrete launch azimuths
3 injection opportunities
5 launch days

Requirements: 1560 numbers

II. Targeting Objectives and First Guesses. A group of parameters, including the launch vehicle targeting objectives, are used to compute the first guesses for the full-mission optimization sequences from earth parking orbit and the translunar coast trajectory. The chart below classifies the parameters.

| | $h_{pc}$ | $\phi_{pc}$ | $I_{fr}$ | $TLI_{ign}$ | $T_{pc}$ | $\lambda_{pc}$ | $R_p$ |
|---|---|---|---|---|---|---|---|
| LV targeting objectives | ✓ | ✓ | ✓ | ✓ | | | |
| Parameters used to compute TLI first guesses | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| Parameters used to compute translunar midcourse (TLMC) first guesses | ✓ | ✓ | ✓ | | ✓ | ✓ | |

[2]The RTCC TLI polynomials are described in reference 3.

Parameters: $h_{pc}$, $\phi_{pc}$, $I_{fr}$, $TLI_{ign}$, $T_{pc}$, $\lambda_{pc}$, $R_p$

Dimensions per parameter: 10 discrete azimuths

3 injection opportunities

5 launch days

Requirements: 1050 numbers

III. Full-mission select mode. The objective of the full-mission select mode is to select a lunar trajectory which satisfies the constraints of the nominal guesses enabling the select mode to determine the values which satisfy trajectory profile objectives.

Parameters: $\gamma_{LOI}$, $\Delta\psi_{LOI}$, $\Delta T_{LLS}$, $T_{LO}$, $\Delta\psi_{TEI}$, $\Delta V_{TEI}$

Dimensions per parameter: 6 discrete azimuths

3 injection opportunities

5 launch days

Requirements: 540 numbers

IV. Polynomial constraint on DPS abort. For nonfree-return trajectories, a constraint is in the process of development to assure LM/DPS return-to-earth abort capability for backup in case of an SPS failure at LOI. This constraint will be implemented in the form of a polynominal and is a function of inclination at pericynthion and trip time from TLI to pericynthion. One polynomial will be required for each launch day, and each polynomial is expected to require seven coefficients.

Number of polynomials: 5

Number of coefficients: 7

Requirements: 35 numbers

V. MAX $\Delta T_{TLI-pc}$. The lunar mission requirements constrain the lunar touchdown to occur within specified sun elevation angles. The purpose of the maximum trip time constraint is to assure that the lunar landing will occur within the sun elevation constraints.

Parameter: MAX $\Delta T_{TLI-pc}$

Dimensions per parameter: 6 discrete azimuths

3 injection opportunities

5 launch days

Requirements: 90 numbers

VI. Earth Orbit Insertion State Vector. Since a complete simulation of the Saturn V launch from lift-off to EOI has been deleted from RTCC requirements, it is necessary to supply the RTCC with the nominal EOI state vector for premission planning. The information defining the state vector will be stored in the form of three constants, the associated coefficients for four polynomials, and one parameter. The polynomials will determine the following quantities:

1. delta time ($\Delta T$) from lift-off to EOI

2. inertial azimuth ($\psi_{eoi}$) at EOI

3. declination ($\phi_{eoi}$) at EOI

4. longitude ($\lambda_{eoi}$) at EOI

Each polynomial requires four coefficients. The single parameter, reference time of lift-off ($T_{LO}$), is a function of launch day only.

Constants: $R_{EOI}$, $V_{EOI}$, $\gamma_{EOI}$

Polynomials: 4

Coefficients per polynomial: 4

Parameter: 1 (function of launch day only)

Requirements: 24 numbers

VII. TLI polynomials. These polynomials provide empirical simulations of the TLI maneuver for both nominal and alternate missions. The coefficients are stored in the RTCC preflight. A brief description of the polynomials is provided in table II.

Polynomials: 10

Coefficients: 238

Requirements: 238 numbers

VIII. Other parameters dimensioned. Five parameters remain which cannot be functionally categorized. Four of these parameters are a function of launch day only and the single parameter is a function of launch azimuth and launch day. Table I provides a definition of the parameters.

Parameters (4): $\phi_{lls}$, $\psi_{lls}$, $\lambda_{lls}$, $\theta_{eo}$

Dimensions per parameter: 5 launch days

Parameter (1): $T_{msn}$

Dimensions per parameter: 6 discrete azimuths

5 launch days

Requirements: 50 numbers

IX. Constants. Fourteen constants exist which cannot be relegated to any single functional category. These constants are defined in table I.

Constants: 11 numbered 27-37 in table I

Requirements: 11 numbers

The preflight data outlined above are generated by the various sections in MAB. Most of the preflight information is generated from data in the launch vehicle and spacecraft reference and operational trajectories. The launch vehicle reference trajectory is available 7 months prior to launch; the operational trajectory, 3 to 5 months prior to launch. The spacecraft reference trajectory is available about 10 months prior to launch, and the operational trajectory about 3 months prior to launch. However, a complete update of the spacecraft operational trajectory can be made as late as 3 weeks prior to lift-off. After receiving the data source, additional time is required by MAB to generate and verify the preflight information. Table III gives the responsible section for each area of preflight data, the earliest date the data source is available, and a preliminary estimate of the time required for output and verification of the preflight information after the data source has been received.

# POWERED-FLIGHT PROCESSOR

This section describes the parameters and constants associated with the Powered-Flight Processor. At the time of this writing, no polynominals have been included in the processor formulation.

As stated in the introduction, this note does not include the preflight numbers for the S-IVB burn model. A prototype of the model[3] exists but the exact mode of implementation is not known. Early development flights of the S-IVB propulsion system will determine the mode of implementation.

The prototype burn model specifies thrust level and specific impulse as a function of time through the burn and predicts the mixture ratio shift. Implementation of this mode into the RTCC could result in a simple table-lookup scheme, or the resultant empirical model could be a more sophisticated system utilizing as many as 13 or 14 polynomials.

The RTCC formulation of the Powered-Flight Processor is described in reference 4.

The Powered-Flight Processor requires 1486 numbers to be stored preflight. The sum associated with each grouping is shown below.

| | | Numerical quantities |
|---|---|---|
| Parameters (22) | | 1460 |
| Constants (26) | | 26 |
| | TOTAL | 1486 |

The 48 parameters and constants can be categorized into groups containing similar characteristics. These groups their associated requirements are:

| | | | Numerical requirements |
|---|---|---|---|
| I. | Hypersurface | | 1350 |
| II. | Parameters which are a function of injection opportunity and launch day | | 45 |
| III. | Parameters which are a function of launch day | | 65 |
| IV. | Constants | | 26 |
| | | TOTAL | 1486 |

[3]A description of the S-IVB burn model is provided in reference 4.

The dimensioning of the groups is briefly described below.

I. Hypersurface. The hypersurface is an onboard S-IVB targeting scheme based on empirical data and is completely described in reference 4. The following parameters completely define the hypersurface and comprise part of the preflight data. Table IV gives the definition of each of these parameters.

Parameters: $\cos\sigma$, $C_3$, $eN_n$, RA, DEC, TT

Dimensions per parameter: 15 discrete azimuths
3 injection opportunities
5 launch days

Requirements: 1350 numbers

II. Parameters which are a function of injection opportunity and launch day.

Parameters: $T_{stj}$, $\beta_j$, $\alpha^*_{tsj}$ (table IV)

Dimensions per parameter: 3 injection opportunities
5 launch days

Requirements: 45 numbers

III. Parameters which are a function of launch day.

Parameters: 13 quantities numbered 47-59 in table IV.

Dimensions per parameter: 5 launch days

Requirements: 65 numbers

IV. Constants

Constants: 26 constants numbered 60-85 in table IV.

Requirements: 26 numbers

All of the above information is generated from the launch vehicle guidance presettings. The earliest data source available for the launch vehicle guidance presettings is the launch vehicle reference trajectory.

This document is published by the Marshall Space Flight Center 7 months prior to the nominal mission launch date. Once this information has been received, the generation and verification of the preflight numbers will take 1 week. The primary source of responsibility for production of these numbers rests with the Maneuver Analysis Section of MAB.

## RETURN-TO-EARTH PROCESSOR[4]

This section defines the constants, coefficients and numbers associated with the Return-to-Earth Processor. There are 249 numerical quantities required as preflight information for the processor. These quantities can be grouped into three categories: 14 constants, 115 coefficients, and an aggregate of 120 numbers. The fourteen constants are enumerated and defined in table V.

The remaining preflight information is associated with the reentry computations for the return-to-earth trajectories. The coefficients, 115 numbers, are required for the reentry curve fits. The reentry curve fits give the downrange, crossrange, and time from reentry to landing as a function of reentry state parameters. This information enables the processor to simulate a reentry profile for a landing state.

The remaining numbers, 120, are stored in table-lookup form and define the reentry target lines. The velocity and flight-path angle values stored in the table assure the spacecraft of a safe reentry. Current formulation of the reentry simulation for the processor specifies two reentry target lines. Each target line requires 60 numbers for adequate definition.

Prime responsibility for those constants associated with reentry (L/D, $RR_{ems}$, $RR_{gn}$, $I_{r\ max}$, $V_{r\ max}$, $R_{ave}$), the reentry target lines, and the reentry curve fits rest with the Reentry Studies Section. Maneuver Analysis Section will provide the definition for the remaining constants. All numbers are now in the process of definition and should be available in the near future. The RTCC formulation for the processor is contained in reference 5.

[4]Reference 5 defines the RTCC formulation for the processor.

## REENTRY PROCESSOR

The Reentry Processor requires 173 numbers as preflight data. Of these numbers, 68 are constants defined in table VI as guidance and DAP gains and constants.

The remaining 105 numbers describe the final phase reference trajectory. The final phase reference trajectory is a stored table of trajectory parameters based on a half-lift, nominal trajectory from which spacecraft steering commands are derived. The trajectory table is described on page 17 of reference 6, which also describes the RTCC formulation of the Reentry Processor.

The RTCC formulation documents the numerical values associated with each of the above quantities. The Reentry Studies Section considers these numerical values to be the nominal mission numbers for the lunar flights. The numbers will be subject to update; the responsibility for documentation of the updated numbers rests with the Reentry Studies Section.

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS ASSOCIATED WITH THE MCC AND TLI PROCESSORS.

| Parameter or constant | Nominal quantity | Processor utilizing parameter | | | Definition |
|---|---|---|---|---|---|
| | | TLI | MCC | Powered flight | |
| 1. $T_{nd}$ | 390 | √ | √ | | Time of arrival at the node |
| 2. $\phi_{nd}$ | 390 | √ | √ | | EMP latitude at the node |
| 3. $\lambda_{nd}$ | 390 | √ | √ | | EMP longitude at the node |
| 4. $R_{nd}$ | 390 | √ | √ | | Radius of node |
| 5. $H_{pc}$ | 150 | √ | √ | | Altitude at pericynthion |
| 6. $\phi_{pc}$ | 150 | √ | √ | | EMP latitude at pericynthion |
| 7. $\lambda_{pc}$ | 150 | √ | √ | | EMP longitude at pericynthion |
| 8. $I_{fr}$ | 150 | √ | √ | | Inclination of the free-return trajectory with respect to the earth's equatorial plane |
| 9. $TLI_{ign}$ | 150 | √ | √ | | Nominal time of translunar injection |
| 10. $T_{pc}$ | 150 | √ | √ | | Time of arrival at pericynthion |
| 11. $\delta$ | 1 | √ | | | Declination of target vector |
| 12. $\sigma$ | 1 | √ | | | Perigee ring half-angle |
| 13. $R_{pc}$ | 1 | √ | | | Nominal radius at pericynthion |
| 14. $\gamma_{loi}$ | 90 | √ | √ | | Flight-path angle at lunar orbit insertion |
| 15. $\Delta\psi_{loi}$ | 90 | √ | √ | | Change in azimuth at lunar orbit insertion |

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS ASSOCIATED WITH THE MCC AND TLI PROCESSORS. - Continued

| Parameter or constant | Nominal quantity | Processor utilizing parameter | | | Definition |
|---|---|---|---|---|---|
| | | TLI | MCC | Powered flight | |
| 16. $\Delta T_{lls}$ | 90 | ✓ | ✓ | | Flight time from lunar orbit insertion to first pass over the lunar landing site |
| 17. $T_{lo}$ | 90 | ✓ | ✓ | | Total time spent in lunar orbit |
| 18. $\gamma_{tei}$ | 90 | ✓ | ✓ | | Flight-path angle at transearth injection |
| 19. $\Delta V_{tei}$ | 90 | ✓ | ✓ | | ΔV at transearth injection |
| 20. MAX $\Delta T_{tli\ pc}$ | 90 | ✓ | ✓ | | Maximum trip time from translunar injection to pericynthion |
| 21. $T_{msn}$ | 30 | ✓ | ✓ | | Total mission time |
| 22. $\phi_{lls}$ | 5 | ✓ | ✓ | | Selenographic latitude of the lunar landing site |
| 23. $\lambda_{lls}$ | 5 | ✓ | ✓ | | Selenographic longitude of the lunar landing site |
| 24. $\psi_{lls}$ | 5 | ✓ | ✓ | | Azimuth over the lunar landing site |
| 25. $T_{LO}$ | 5 | ✓ | ✓ | ✓ | Reference time of lift-off |
| 26. $\theta_{eo}$ | 5 | ✓ | ✓ | ✓ | Right ascension of launch site |

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS ASSOCIATED WITH THE MCC AND TLI PROCESSORS. - Concluded

| Parameter or constant | Nominal quantity | Processor utilizing parameter | | | Definition |
|---|---|---|---|---|---|
| | | TLI | MCC | Powered flight | |
| 27. $\Delta T_6$ | 1 | ✓ | ✓ | ✓ | Delta time from time base six to S-IVB injection |
| 28. YEAR | 1 | ✓ | ✓ | | Year of launch |
| 29. $M_a$ | 1 | ✓ | | | Adapter mass |
| 30. $M_{cm}$ | 1 | ✓ | ✓ | | Command module (Structure + 3 crew members + equipment + RCS fuel + life systems) mass |
| 31. $M_{sm}$ | 1 | ✓ | ✓ | | Service module (not including unusuable fuel) mass |
| 32. $M_{uf}$ | 1 | ✓ | ✓ | | Mass of unusable fuel |
| 33. $H_{lo}$ | 1 | ✓ | ✓ | | Altitude at start of lunar parking orbit |
| 34. $T_{ls}$ | 1 | ✓ | ✓ | | Lunar stay time |
| 35. $R_{eoi}$ | 1 | ✓ | | | Nominal radius at pericynthion |
| 36. $\gamma_{eoi}$ | 1 | ✓ | | | Inertial flight-path angle at earth orbit insertion |
| 37. $V_{eoi}$ | 1 | ✓ | | | Inertial velocity at earth orbit insertion |

TABLE II.- COEFFICIENTS FOR THE TLI POLYNOMIALS ASSOCIATED WITH THE MCC AND TLI PROCESSORS

(a) Nominal mission

| Parameter | Number of coefficients |
|---|---|
| $\alpha$ | 24 |
| $\beta$ | 28 |
| $\eta + \alpha$ | 24 |
| $r_p$ | 24 |
| $\Delta V$ | 24 |
| Total | 124 |

(b) Alternate mission

| Parameter | Number of coefficients |
|---|---|
| $\alpha$ | 28 |
| $\beta$ | 32 |
| $\eta + \alpha$ | 28 |
| $r_p$ | 28 |
| $\Delta V$ | 28 |
| Total | 144 |

TABLE III.- TLI AND MCC PROCESSOR INFORMATION

| Area | Source | Agency responsible | Earliest date source available prior to mission, months | Output plus verification, weeks |
|---|---|---|---|---|
| Nodal targeting | LV and SC target objectives | LMDS and MAS | 10 | 1 |
| First guess computation | LV target objectives | LTS | 7 | 1 |
| Full-mission select mode | SC and LV target objectives | LTS | 10 | 1 |
| Constraint on DPS abort | LV and SC target objectives plus constraint from FAB | LTS and MAS | 10 | 1 |
| Maximum $\Delta T_{tli\ pc}$ | Parametric data | LTS | 9 1/2 | 2 |
| Earth orbit insertion state vector | LV OT | LMDS | 3-5 | 1 |
| TLI polynomials | TRW | MAS | --- | --- |
| $T_{msn}$, $\phi_{lls}$, $\lambda_{lls}$, $\psi_{lls}$ YEAR, $H_{lo}$, $T_{ls}$, $R_{pc}$ | ASPO and MAB | LTS | --- | --- |
| $T_{LO}$, $\theta_{eo}$, $\Delta T_6$ | LV OT | MAS | 3-5 | --- |
| $\sigma$, $\delta$ | Parametric data | LMDS | available now | --- |
| $M_a$, $M_{cm}$, $M_{sm}$, $M_{uf}$ | ? | ? | ? | ? |
| $(R, V, \gamma)_{eoi}$ | LV RT | LMDS | 7 | --- |

TABLE IV.- DEFINITION OF PARAMETERS AND CONSTANTS

ASSOCIATED WITH THE POWERED-FLIGHT PROCESSOR

| Parameter or constant | Numerical quantity | Definition |
|---|---|---|
| 38. $\cos \sigma$ | 225 | Arc radius of perigee circle |
| 39. $C_3$ | 225 | Desired cutoff energy |
| 40. $e_n$ | 225 | Desired eccentricity at cutoff |
| 41. RA | 225 | Right ascension of target vector |
| 42. DEC | 225 | Declination of target vector |
| 43. TT | 225 | Difference in time of launch from reference time of launch |
| 44. $T_{ST_j}$ | 15 | Coast time in EPO before restart test is entered for desired injection opportunity |
| 45. $\beta_j$ | 15 | Central angle from radial at restart preparation initiation to node of EPO plane and desired cutoff plane |
| 46. $\alpha^*_{TS_j}$ | 15 | Central angle from nodal vector, $\bar{S}$, to target vector, $\bar{T}$, at restart preparation initiation |
| 47. f | 5 | Estimate of terminal range angle |
| 48. $K_1$ | 5 | Coefficient of $\alpha_{ts}$ polynomial |
| 49. $K_2$ | 5 | Coefficient of $\alpha_{ts}$ polynomial |
| 50. $\omega_e$ | 5 | Earth's rotational rate-sidereal |
| 51. DTGM | 5 | Constant delta time from TB6 to the time at which IGM is entered |
| 52. $K_{pl}$ | 5 | Coefficient of pitch polynomial |

TABLE IV.- DEFINITION OF PARAMETERS AND CONSTANTS ASSOCIATED WITH THE POWERED-FLIGHT PROCESSOR - Continued

| Parameter or constant | Numerical quantity | Definition |
|---|---|---|
| 53. $K_{p2}$ | 5 | Coefficient of pitch polynomial |
| 54. $K_{y1}$ | 5 | Coefficient of yaw polynomial |
| 55. $K_{y2}$ | 5 | Coefficient of yaw polynomial |
| 56. $R_n$ | 5 | Nominal radius at ignition |
| 57. $T_3'$ | 5 | Estimate of third (guidance) stage burn time |
| 58. $K_{t3}$ | 5 | Coefficient used to determine $T_3$ |
| 59. $\tau_3$ | 5 | Estimate of burn time for vehicle depletion during third IGM stage |
| 60. $\phi_L$ | 1 | Geodetic latitude of launch site |
| 61. $T_2$ | 1 | Second (guidance) stage burn time |
| 62. $V_{ex2}$ | 1 | Exhaust velocity - second IGM stage |
| 63. $V_{ex3}$ | 1 | Exhaust velocity - third IGM stage |
| 64. $\dot{M}_2$ | 1 | Mass flow rate - second IGM stage |
| 65. $\dot{M}_3$ | 1 | Mass flow rate - third IGM stage |
| 66. $T_{b2}$ | 1 | Transition time for mixture ratio shift |
| 67. $K_{pc}$ | 1 | Constant used to force mixture ratio in IGM shift |
| 68. $\varepsilon_1$ | 1 | Estimated burn time |
| 69. $\varepsilon_2$ | 1 | Estimated burn time |

TABLE IV.- DEFINITION OF PARAMETERS AND CONSTANTS ASSOCIATED

WITH THE POWERED-FLIGHT PROCESSOR - Concluded

| Parameter or constant | Numerical quantity | Definition |
|---|---|---|
| 70. $\varepsilon_3$ | 1 | Estimated burn time |
| 71. $\varepsilon_4$ | 1 | Estimated burn time |
| 72. RØT | 1 | Flag: if RØT = 1, terminal conditions rotated; if RØT ≠ 1, terminal conditions not rotated |
| 73. RØV | 1 | Constant for biasing terminal range angle prediction |
| 74. $\Delta V_b$ | 1 | Velocity cutoff bias |
| 75. $V_{tc}$ | 1 | Velocity parameter used in cutoff logic |
| 76. $\dot{\chi}_{y1}$ | 1 | Maximum allowable pitch rate |
| 77. $\dot{\chi}_{z1}$ | 1 | Maximum allowable yaw rate |
| 78. $\tau_{2n}$ | 1 | Parameter used in artificial tau modes |
| 79. $\tau_{3n}$ | 1 | Parameter used in artificial tau modes |
| 80. $C'$ | 1 | Parameter used in artificial tau modes |
| 81. $C'_o$ | 1 | Parameter used in artificial tau modes |
| 82. $\Delta T_{4m}$ | 1 | Limit on difference in burn time, first S-IVB burn |
| 83. $\Delta t_a$ | 1 | Time increment from ignition to 90% thrust |
| 84. $\Delta t_b$ | 1 | Time increment from 90% thrust to thrust at mixture ratio 1 |
| 85. $\Delta t_m$ | 1 | Time increment from mixture ratio shift to "leveling out" of thrust at mixture ratio 2 |

TABLE V.- DEFINITION OF CONSTANTS ASSOCIATED WITH THE ABORT PROCESSOR

| Constant | Numerical quantity | Definition |
|---|---|---|
| 86. $H_{pc\ min}$ | 1 | Minimum acceptable pericynthion altitude for abort trajectories |
| 87. (L/D) | 1 | Current value of lift-to-drag needed by the reentry curve fits |
| 88. $RR_{ems}$ | 1 | Reentry range bias used to produce the range function for the EMS mode |
| 89. $RR_{gn}$ | 1 | Nominal reentry down range to the target impact point for the G and N mode in the EFCUA mode |
| 90. $MD_{max}$ | 1 | Maximum miss distance used in the tradeoff displays |
| 91. $\Delta MD$ | 1 | Miss distance increment used in the tradeoff displays |
| 92. $R_{a\ max}$ | 1 | Abort radius limit for the EFCUA solution in the FCUA mode of the earth phase logic |
| 93. $T_{armin}$ | 1 | Minimum flight time between abort and reentry |
| 94. $I_{r\ max}$ | 1 | Maximum inclination at reentry |
| 95. $V_{r\ max}$ | 1 | Maximum reentry speed |
| 96. $R_{ave}$ | 1 | Mean radius at reentry |
| 97. $e_{NE/RE}$ | 1 | Eccentricity test value that selects either the NE or RE option in the tradeoff display |
| 98. $R_{msi}$ | 1 | Radius magnitude of the moon's sphere of influence utilized with the conic package |
| 99. $R_{a\ min}$ | 1 | Minimum abort radius |

TABLE VI.- DEFINITION OF CONSTANTS ASSOCIATED

WITH THE REENTRY PROCESSOR

(a) Guidance gains and constants

| Constant | Numerical quantity | Definition |
|---|---|---|
| 100. C1 | 1 | Factor in ALP computation |
| 101. C16 | 1 | Constant gain on drag |
| 102. C17 | 1 | Constant gain on RDOT |
| 103. C18 | 1 | Bias velocity for final phase start |
| 104. C20 | 1 | Maximum drag for down-lift |
| 105. CHOOK | 1 | Factor in AHOOK computation |
| 106. CHI | 1 | Factor in GAMMAL computation |
| 107. D2 | 1 | Drag for changing values of LEWD |
| 108. DT | 1 | Computation cycle-time interval |
| 109. GMAX | 1 | Maximum acceleration |
| 110. KA1 | 1 | Factor in KA computation |
| 111. KA2 | 1 | Factor in KA computation |
| 112. KA3 | 1 | Factor in DO computation |
| 113. KA4 | 1 | Factor in DO computation |
| 114. KB1 | 1 | Optimized upcontrol gain |
| 115. KB2 | 1 | Optimized upcontrol gain |
| 116. KDMIN | 1 | Increment on Q7 to detect end of Kepler phase |
| 117. KLAT | 1 | Lateral switch gain |

TABLE VI.- DEFINITION OF CONSTANTS ASSOCIATED

WITH THE REENTRY PROCESSOR - Continued

| Constant | Numerical quantity | Definition |
|---|---|---|
| 118. KTETA | 1 | Time of flight constant |
| 119. TN | 1 | Nominal time of flight |
| 120. K13P | 1 | Constant in FINAL PHASE |
| 121. LAD | 1 | Maximum L/D |
| 122. L/D CMINR | 1 | LAD cosine (15°) |
| 123. LEWD1 | 1 | Upcontrol L/D |
| 124. LEWD2 | 1 | Upcontrol L/D |
| 125. LOD | 1 | Final phase L/D |
| 126. POINT 1 | 1 | Factor to reduce upcontrol gain |
| 127. Q2 | 1 | Final phase range - 23 500 Q3 |
| 128. Q3 | 1 | Final phase D range/DV |
| 129. Q5 | 1 | Final phase D range/D GAMMA |
| 130. Q6 | 1 | Final phase initial flight-path angle |
| 131. Q7MIN | 1 | Constant in FACTOR |
| 132. Q7F | 1 | Minimum drag for upcontrol |
| 133. Q19 | 1 | Constant in GAMMAL 1 |
| 134. VSLOW | 1 | If V less than VSLOW, LEWD = 0.2 |
| 135. VLMIN | 1 | Minimum VL |
| 136. VMIN | 1 | Minimum velocity to switch to relative velocity |

TABLE VI.- DEFINITION OF CONSTANTS ASSOCIATED
WITH THE REENTRY PROCESSOR - Continued

| Constant | Numerical quantity | Definition |
|---|---|---|
| 137. VRCONTROL | 1 | RDOT to start into HUNTEST |
| 138. 25 NM | 1 | Tolerance to stop range iteration |
| 139. LATBIAS | 1 | Lateral switch bias term |
| 140. VQUIT | 1 | Velocity to stop steering |
| 141. K44 | 1 | Initial attitude gain |
| 142. VFINAL 1 | 1 | Velocity to start final phase on INITENTRY |
| 143. VFINAL | 1 | Factor in initial attitude |
| 144. VCORLIM | 1 | Maximum values of VCORR |
| 145. ATK | 1 | Angle in RAD to NM |
| 146. GS | 1 | Nominal value of G for scaling |
| 147. HS | 1 | Atmosphere scale height |
| 148. RE | 1 | Earth radius |
| 149. VSAT | 1 | Satellite velocity at RE |
| 150. WIE | 1 | Earth rate |
| 151. KWE | 1 | Equatorial earth rate |
| (b) DAP gains and constants | | |
| 152. ANGMAX | 1 | Maximum angular velocity allowed about the X-body axis |
| 153. A1 | 1 | Acceleration term used to calculate firing intervals |
| 154. A2 | 1 | Acceleration term used to calculate firing intervals |

TABLE VI.- DEFINITION OF CONSTANTS ASSOCIATED

WITH THE REENTRY PROCESSOR - Concluded

| Constant | Numerical quantity | Definition |
|---|---|---|
| 155. KLAG1 | 1 | Interval switching logic to fire appropriate roll jets or to coast |
| 156. KLAG2 | 1 | Interval switching logic to fire appropriate roll jets or to coast |
| 157. KLAG3 | 1 | Interval switching logic to fire appropriate roll jets or to coast |
| 158. M | 1 | Interval counter to allow implementation of roll commands on 0.1-second intervals |
| 159. RAEMIN | 1 | Roll deadband |
| 160. SLOPE | 1 | Factor to obtain desired rate of error reduction |
| 161. SWTCH1 | 1 | Internal switching to delay roll command |
| 162. SWTCH2 | 1 | Internal switching to delay roll command |
| 163. SWTCH3 | 1 | Internal switching to delay roll command |
| 164. TIMINT | 1 | Integration time interval |
| 165. TMAX | 1 | DAP sampling frequency for time interval of TIMINT |
| 166. VZ | 1 | Roll rate deadband |
| 167. XS | 1 | Control line intercept value |

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